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A COMPARATIVE EVALUATION OF THE 7.62MM AND 5.56MM, G-3 ASSAULT RIFLES

by

Thomas E. Carlson
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U.S. ARMY ABERDEEN RESEARCH AND DEVELOPMENT CENTER
BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

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BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 1953

JANUARY 1969

A COMPARATIVE EVALUATION OF THE 7.62mm AND 5.56mm, G-3 ASSAULT RIFLES

Thomas E. Carlson
David A. Golm

Interior Ballistics Laboratory

RDT&E Project No. 1W523801A304

ABERDEEN PROVING GROUND, MARYLAND

B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

MEMORANDUM REPORT NO. 1953

TECarlson/DAGolm/nlg
Aberdeen Proving Ground, Md.
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A COMPARATIVE EVALUATION OF THE 7.62mm AND 5.56mm, G-3 ASSAULT RIFLES

ABSTRACT

A test was conducted with 7.62mm and 5.56mm, G-3 Assault Rifles to evaluate and compare the kinematics, reliability, safety features, physical characteristics, recoil impulse, rates of fire, projectile velocities, muzzle motion and accuracy of the weapons. No serious problems were detected during the tests and the reliability of the weapons was comparable.

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LIST OF SYMBOLS

F_1 — force required on the face of the bolt to release the locking mechanism, lb

F_2 — force required on the connecting rod to release the locking mechanism, lb

F_s — force applied by the bolt latch spring, lb

h — distance measured vertically from center of bore to center of buttplate, in.

I_{bp} — moment of inertia about a horizontal transverse axis passing through the center of buttplate, lb ft sec^2

I_{cg} — moment of inertia about a horizontal transverse axis passing through the center of gravity, lb ft sec^2

J — recoil impulse, lb sec

N — number of rounds in statistical sample

R — rate of fire, shots per min (SPM)

V — velocity of bolt assembly, ft per sec (fps)

V_m — muzzle velocity of projectile, ft per sec (fps)

X_{cg} — distance measured parallel to bore from center of buttplate, in.

Y_{cg} — distance measured vertically from center of bore to center of gravity, in.

α — angle of mating surfaces on bolt and bolt latch, deg

θ — angle of ramp for locking rollers on connecting rod, deg

σ_J — standard deviation in measured recoil impulse, lb sec

σ_R — standard deviation in rate of fire, shots per minute (SPM)

σ_V — standard deviation in velocities, ft per sec (fps)

ϕ — angle of ramp for locking rollers in locking recesses, deg

I. INTRODUCTION

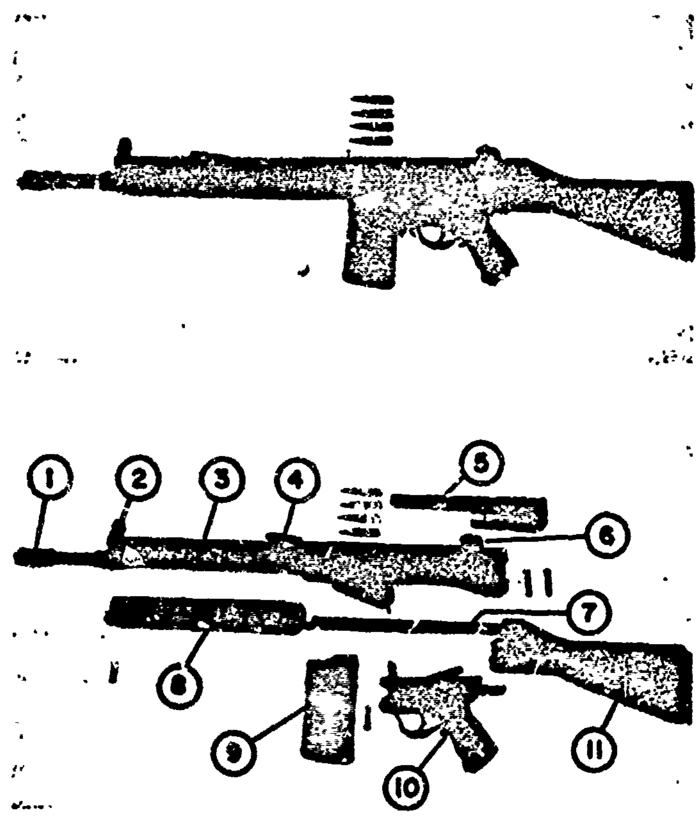
The 7.62mm, G-3 Assault Rifle, which fires the M80 NATO round, has been in use by the German Armed Forces for a number of years. It is essentially an improved version of the earlier Spanish CETME Assault Rifle and has proved quite reliable. It fires in both the semi-automatic and automatic modes and is fed from a 20-round, box-type magazine. Most of the parts of the G-3, with the exception of the barrel and the bolt assembly, are made of stamped sheet steel, which makes the system easy to mass-produce.

The increasing interest in small calibers, particularly 5.56mm, prompted the development of a scaled-down version of the 7.62mm weapon. The scaled-down model, produced by Harrington and Richardson, Inc., of Massachusetts, in association with Heckler and Koch, G. M. B. H. of West Germany, fires the 5.56mm, M193 round. The mechanism of the 5.56mm weapon differs from the 7.62mm version only in a few minor respects. The most notable of these are the addition of a catch to keep the bolt open after the last round of a magazine is fired and the use of a damping device in the bolt assembly of the 5.56mm weapon.

At the request of U.S.A. Weapons Command, two 5.56mm rifles and one 7.62mm rifle were delivered to the Interior Ballistics Laboratory of Aberdeen Proving Ground for test and evaluation. Studies of physical characteristics, kinematics and reliability of the mechanisms, projectile velocities, muzzle vibration and accuracy of fire were requested.

II EQUIPMENT AND PROCEDURE

One 7.62mm, G-3 rifle and two 5.56mm, G-3 rifles were fired during the tests. Gun No. HK 2803 was a 7.62mm rifle on which the history was unknown, but it appeared from the wear of the parts that less than 5000 rounds had been fired from the weapon. The weapons are shown assembled and unassembled in Figures 1 and 2. The weapons were fired under laboratory conditions and in most cases from a machine rest mounted as shown in Figure 3.



1. FLASH SUPPRESSOR
2. FRONT SIGHT
3. BARREL GROUP
4. CHARGING HANDLE
5. BOLT ASSEMBLY
6. REAR SIGHT
7. BOLT RETURN SPRING
8. FOREGRIP
9. MAGAZINE
10. TRIGGER ASSEMBLY AND HANDGRIP.
11. STOCK

Figure I. 7.62 MM, G-3 Assault Rifle, Assembled and Unassembled.

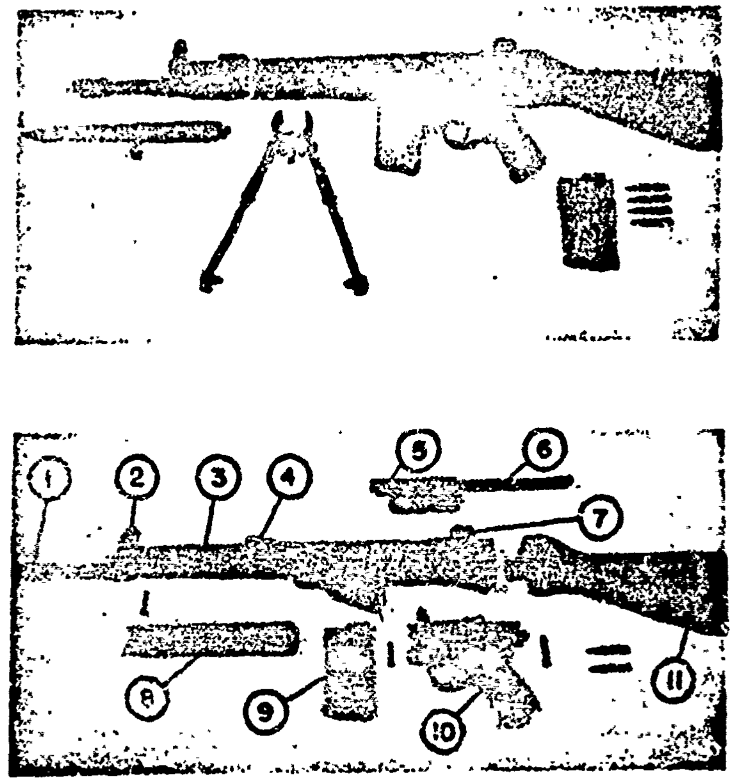


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Figure 2. 5.56 MM, G-3 Assault Rifle, Assembled and Unassembled.

Figure 3. 7.62mm, G-3 Assault Rifle in Machine Rest

Much of the data used in the study was obtained with a displacement-time camera.[1*] To take displacement-time records of the bolt carrier motion, a cylindrical reflector was threaded into a hole in the top of the bolt carrier. A slot was cut in the top of the receiver to allow for travel of the reflector. A reflector was also bolted to the receiver so that the motion of the bolt assembly relative to the receiver could be measured. The camera was focused on the reflector and displacement-time records were taken during firing of the weapon. The bolt assembly with the reflector is shown in Figure 4.

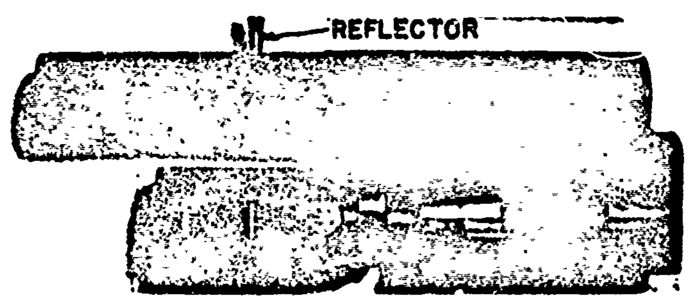

Figure 4. Bolt Assembly with Bolt Carrier Reflector

*References are found on page 45

In some instances it was necessary to record the motion of both the bolt and the bolt carrier. Because the reflector on the bolt was perpendicular to the center line of the reflector on the bolt carrier, a system of mirrors was used to project the images of the reflectors into the camera. The reflector used to record bolt motion is shown in Figure 5.

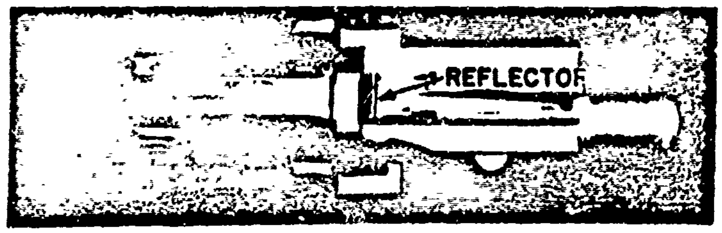

Figure 5. Bolt Assembly with Bolt Reflector

The displacement-time records were used to calculate the velocity and acceleration of the bolt carrier, the rate of fire and to explain irregularities of operation. Studies of minute details of functioning, such as hammer swing or bolt bounce were made when the records indicated unusual or critical behavior in the mechanism. Displacement-time records of the muzzle motion were taken by focusing the camera on a reflector epoxied to the outer wall of the barrel at the muzzle. The records were used to determine the frequency and amplitude of muzzle vibrations.

Four lumaline screens were used to determine projectile velocities at three points along the trajectory. The times elapsed while the projectile traveled between screens were recorded with digital counters. Using these times and the distances between the screens, the average velocities between screens were calculated and the velocity at the muzzle was determined by extrapolating from the plotted data.

Some simulated shoulder firing was done for comparison with the firing done in the machine rest. For this purpose a frame was built which allowed the weapon freedom of movement only along the line of recoil and counterrecoil as shown in Figure 6.

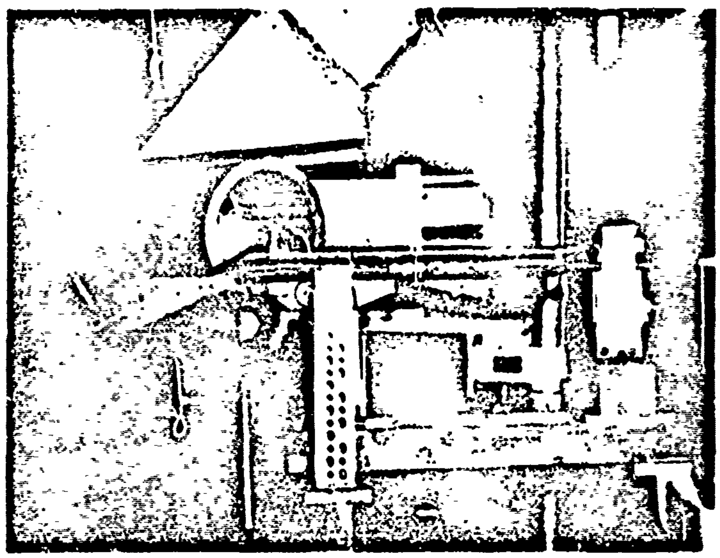

Figure 6. 5.56mm, G-3 Assault Rifle in Mount used for Simulating Shoulder Firing

During firing, the operator shouldered the weapon just as he would when firing without constraints. Displacement-time records of the receiver and bolt carrier were taken during firing.

Recoil impulse was determined by firing the two weapons in a ballistic pendulum with and without muzzle attachments.[2]

III. RESULTS

A. Physical Measurements

Table I. Weights, pounds

COMPONENTS	7.62mm	5.56mm
Weapon Empty	9.430	8.16
Weapon and Magazine	9.740	8.41
Weapon and Magazine + 20 Rounds	10.810	8.91
Sling	- - -	0.27
Bayonet	- - -	0.65
Tripod	- - -	1.015
Bolt	0.220	0.200
Bolt Carrier	1.355	0.900
Connecting Rod	0.085	0.085
Firing Pin	0.020	0.015
Receiver and Barrel Group	4.150	3.940
Trigger Mechanism	1.350	1.040
Stock	1.490	1.150
Foregrip	0.400	0.370

Table II. Lengths, inches

	7.62mm	5.56mm
Weapon, Length, w/ Muzzle Device	40.38	36.88
Weapon, Length, w/o Muzzle Device	39.38	35.72
Barrel, Length, w/o Muzzle Device	17.44	15.44

Table III. Spring Calibrations

Return Spring	7.62mm	5.56mm
Spring Constant	2.2 lb/in.	2.7 lb/in.
Free Length	17.8 in.	14.5 in.
Length in Weapon	12.4 in.	10.9 in.
Initial Load	12.0 lb	9.7 lb
Firing Pin Spring	7.62mm	5.56mm
Spring Constant	7.7 lb/in.	8.3 lb/in.
Free Length	1.55 in.	1.45 in.
Length in Weapon	1.25 in.	1.15 in.
Initial Load	2.3 lb	2.5 lb

Table IV. Moment Arms and Moments of Inertia

Weapon + Magazine		7.62mm	5.56mm
h	(in.)	2.304	2.161
I_{cg}	(lb ft sec^2)	0.1485	0.1054
I_{bp}	(lb ft sec^2)	0.8881	0.6792
X_{cg}	(in.)	18.970	18.280
Y_{cg}	(in.)	0.366	0.246
Weapon + Magazine + Bayonet			
h	(in.)	2.304	2.161
I_{cg}	(lb ft sec^2)	0.1509	0.1422
I_{bp}	(lb ft sec^2)	0.9704	0.3584
X_{cg}	(in.)	18.94	19.620
Y_{cg}	(in.)	0.645	0.093
Weapon + Magazine + 20 Rounds			
h	(in.)	- - -	2.161
I_{cg}	(lb ft sec^2)	- - -	0.1060
I_{bp}	(lb ft sec^2)	- - -	0.7112
X_{cg}	(in.)	- - -	18.22
Y_{cg}	(in.)	- - -	0.361
Weapon + Magazine + 20 Rounds + Bayonet			
h	(in.)	- - -	2.161
I_{cg}	(lb ft sec^2)	- - -	0.143
I_{bp}	(lb ft sec^2)	- - -	0.888
X_{cg}	(in.)	- - -	19.460
Y_{cg}	(in.)	- - -	0.329

NOTE: I_{cg} is the moment of inertia about a horizontal transverse axis passing through the center of gravity, lb ft sec^2.

I_{bp} is the moment of inertia about a horizontal transverse axis passing through the center of the buttplate, lb ft sec^2.

h is the distance measured vertically from center of bore to center of buttplate, in.

Y_{cg} is the distance measured vertically from center of bore to center of gravity, in.

X_{cg} is the distance measured parallel to the bore from center of gravity to the center of the buttplate, in.

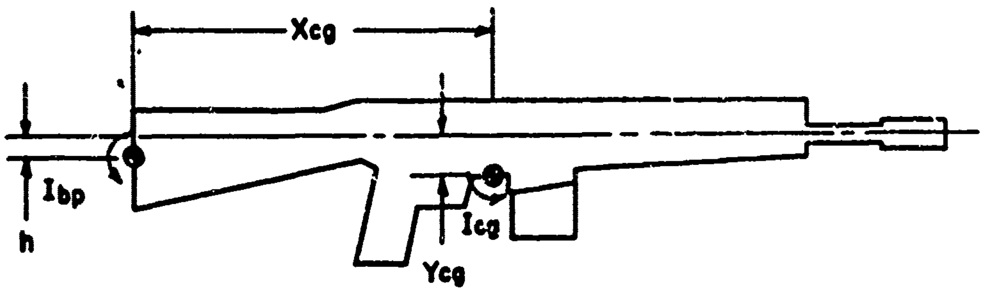

Figure 7. Moment Arms about Center of Gravity and Buttplate

B. Description of Mechanism

The G-3 system is essentially a blowback operated weapon. That is, the chamber pressure during firing overcomes the resistance of the locking mechanism in the bolt and drives the bolt assembly out of battery. Enough momentum is imparted to the bolt assembly during the blowback to drive the system through a complete cycle.

Cycle of functioning The sequence of events during a firing cycle is as follows. After the cartridge primer is struck, the pressure in the chamber rises sharply which pushes the cartridge case back against the face of the bolt. When the force on the bolt is great enough, the locking mechanism releases and the gas pressure accelerates the bolt assembly out of battery. The projectile is out of the barrel by the time the bolt actually unlocks because of the inertia of the bolt assembly and the resistance of the locking mechanism. The bolt assem. . reaches a velocity of about 25 feet per second as it is blown out of battery. Rearward motion of the assembly is opposed by the driving spring and the hammer. After the bolt assembly travels rearward approximately two inches, the hammer is seared. The cartridge case, which has blown out of the chamber, is held to the bolt by the extractor. When the assembly has traveled rearward approximately four inches, the empty case is ejected. The rearward travel of the bolt assembly is arrested at approximately six inches when it strikes the backplate in the stock. The bolt assembly bounces off the backplate and the drive spring, which was compressed during the rearward travel, accelerates the bolt assembly forward toward the battery position. As the bolt assembly reaches a point approximately four inches from battery, it begins to strip the top round from the magazine. Stripping is completed after one inch of forward travel and the round begins to chamber. At 0.25 inch from battery the round is completely chambered and the bolt begins to lock. The hammer is seared off when the bolt assembly reaches 0.10 inch from battery. The hammer strikes the firing pin and drives it into the primer of the round, initiating another cycle. Displacement-time records of the bolt carrier for typical cycles of the 7.62mm and 5.56mm weapons are shown in Figures 8 and 9.

Bolt Assembly The bolt assembly is composed of two major parts; the bolt and the bolt carrier. The bolt carrier, which is the larger of the two, slides on rails in the sides of the receiver and provides a vehicle for the bolt. The top half of the bolt carrier, a tubular section, serves as a guide for the driving spring and as an extension to the charging assembly. The bolt is a hollow steel block which contains two cylindrical steel rollers in slots on either side. In the locked condition (in-battery position) these rollers protrude out of the bolt and press into locking recesses in the sides of the receiver. The bolt rides on a short rod which extends out of the bolt carrier and contains the firing pin.

The Locking and Unlocking Process and the Associated Forces Besides connecting the bolt and bolt carrier, the connecting rod implements locking and unlocking. The ramp surfaces on the front of the connecting rod bear on the locking rollers such that when the rod is pressed into the bolt, the rollers are forced to protrude. Conversely, when the rollers are compressed into the bolt, the rod is squeezed out, separating the bolt and bolt carrier. The locking mechanism is shown in Figure 10.

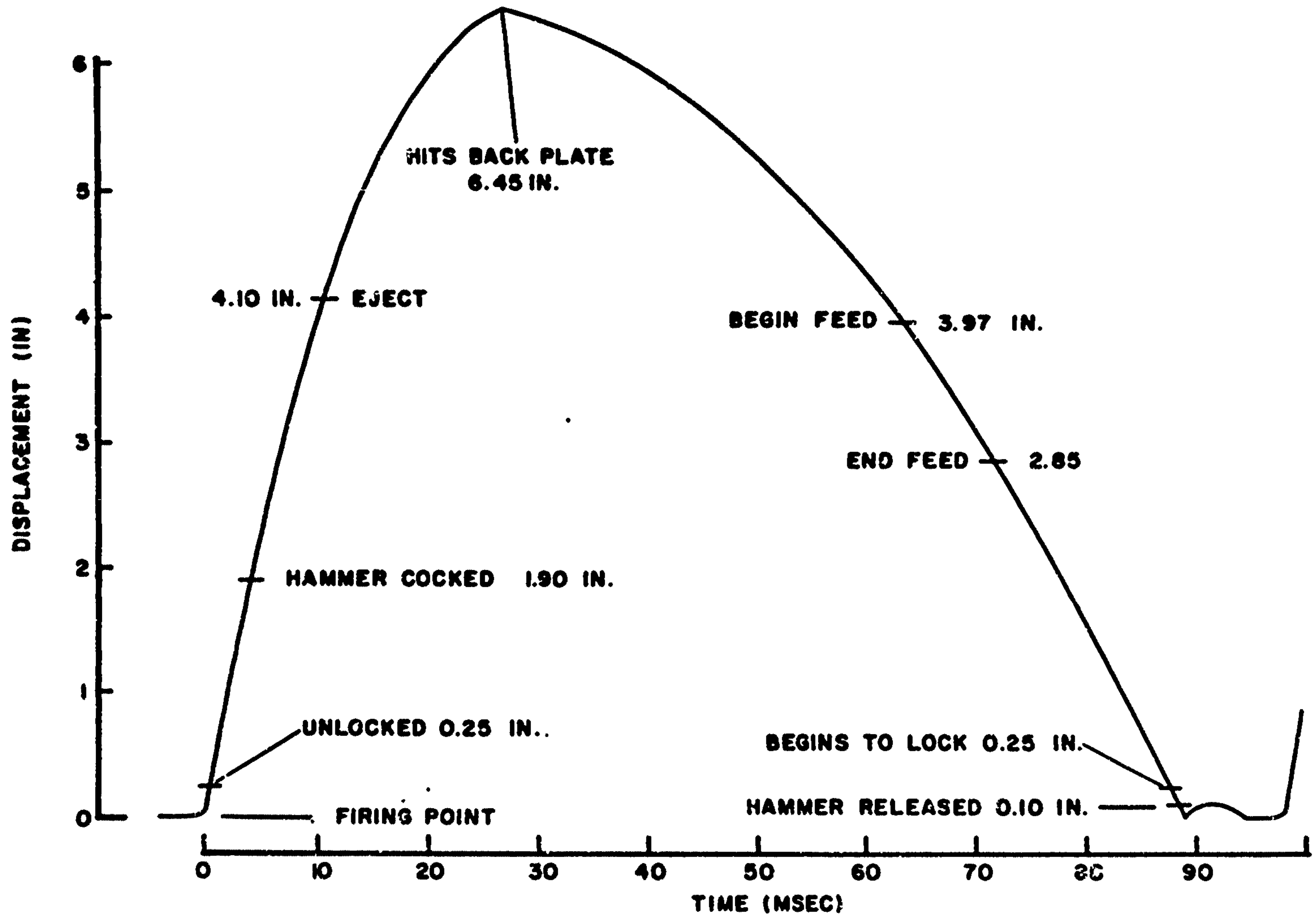

Figure 8. Displacement-Time Record of Bolt Carrier, 7.62MM,G-3.

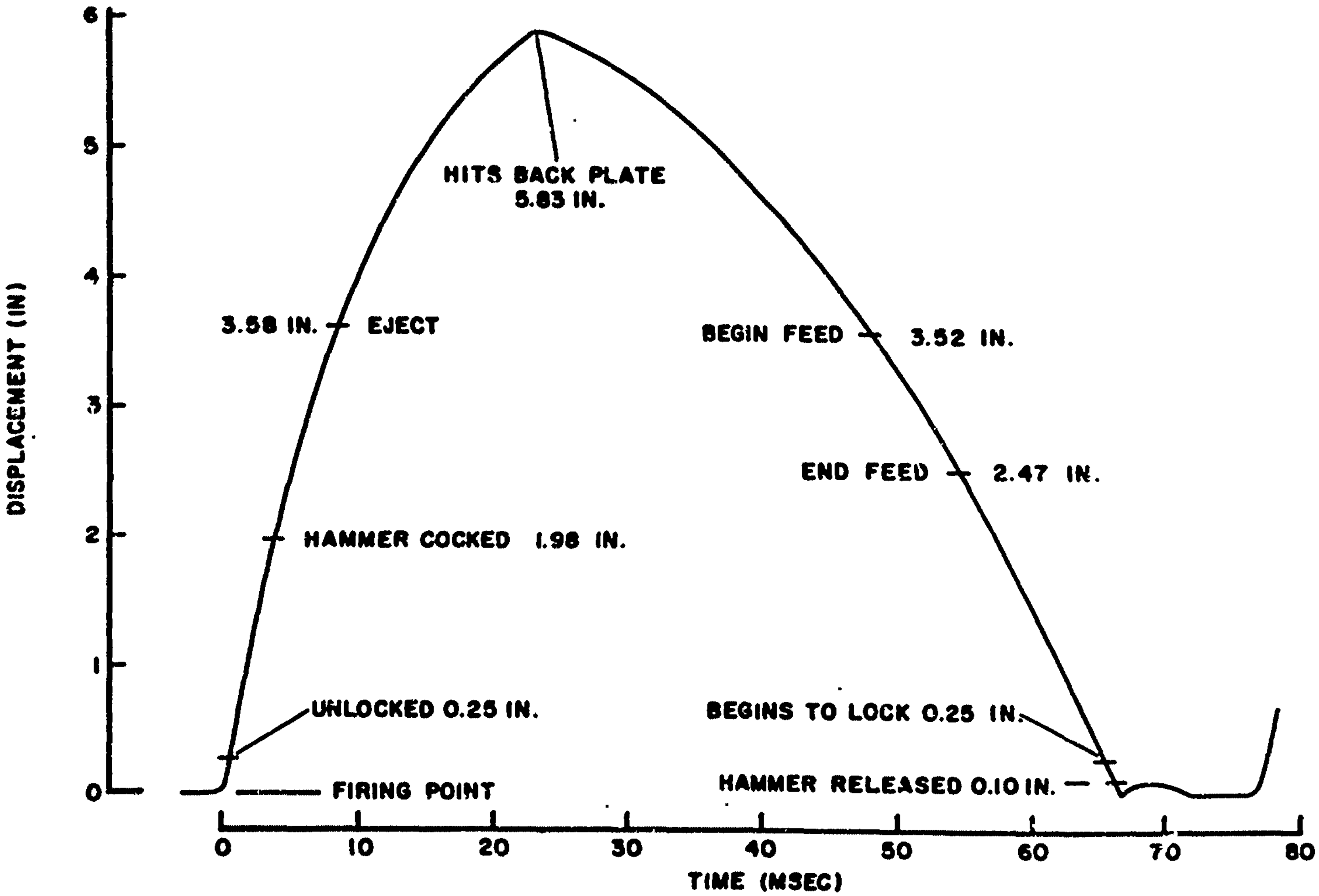

Figure 9. Displacement Time Record of Bolt Carrier, 5.56 MM, G-3.

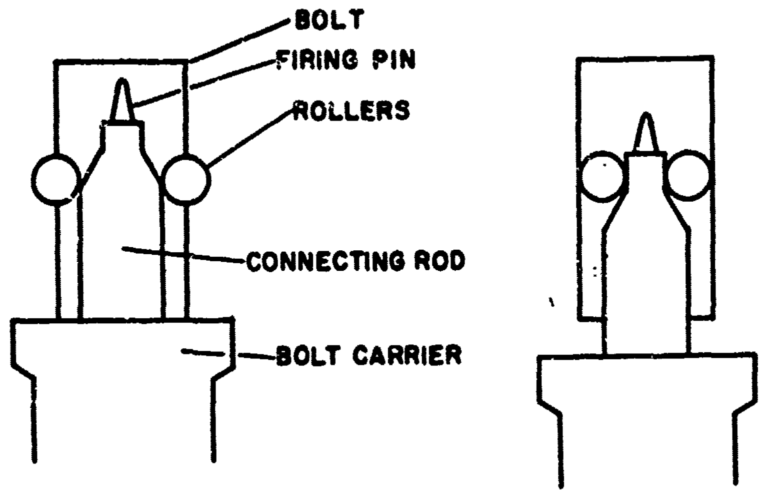

Figure 10. Locking Mechanism

The sequence of events in the locking and unlocking process is as follows. When the bolt assembly comes into battery, the bolt is stopped by the face of the breech. The forward momentum of the bolt carrier thrusts the connecting rod into the bolt, closing the separation between the bolt and bolt carrier and forcing the locking rollers into the recesses in the receiver. As the bolt and bolt carrier come together, a spring loaded latch on the bolt carrier clips onto a lip of the bolt, holding the assembly securely locked in battery. Operation of the bolt latch is illustrated in Figure 11.

When a force is applied to the face of the bolt, the load is taken by the rollers and the locking recesses. The walls of the recesses are angled so that the load tends to compress the rollers into the bolt and squeeze the connecting rod out. The bolt latch, however, opposes any movement by the connecting rod which tends to separate the bolt and bolt carrier. The bearing surface between the bolt and bolt latch is angled slightly though, so when enough pressure is applied to

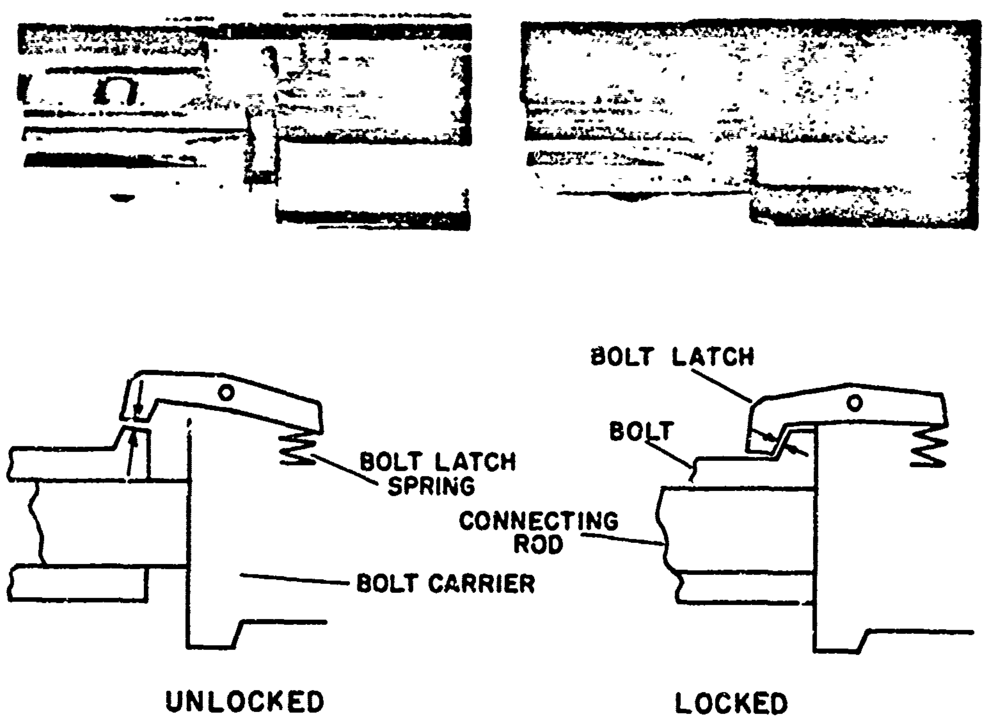

Figure 11. Operation of Bolt Latch

the connecting rod, the latch will release and the bolt will unlock. The net result is that the force on the face of the bolt acting through the rollers and connecting rod must be sufficient to overcome the resistance of the bolt latch.

The mechanical advantage or disadvantage of the system depends on the angles of the locking recesses and ramp surfaces on the connecting rod. Figure 12 shows free body diagrams of the components of the locking mechanism. Frictional forces were not considered. If we sum the forces on the components in each direction we arrive at $F_2 = F_1 \tan \phi / \tan \phi + \tan \theta$. Where F_1 is the force on the face of the bolt, F_2 is the net force on the connecting rod, and θ and ϕ are the angles of the connecting rod surfaces and locking recesses respectively. To unlock, F_2 must be great enough to force the bolt latch to release. That is $F_2 \tan \alpha$

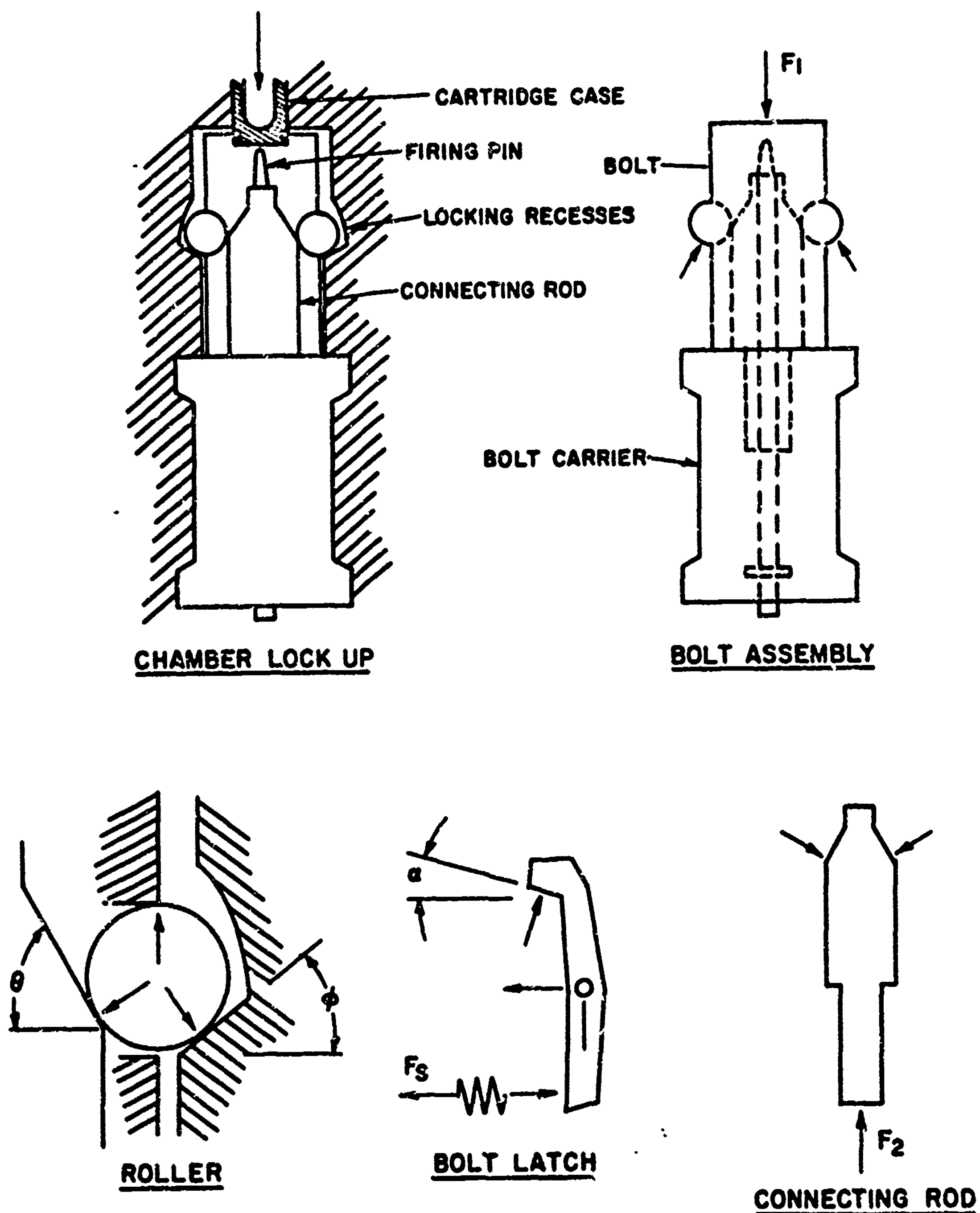

Figure 12. Components of Locking Mechanism

must be larger than F_s, where F_s is the force applied by the bolt latch spring, and α is the angle on the lip of the bolt latch.

The angle θ measured 60° on each of the weapons tested. The angle ϕ could not be measured accurately but was between 30° and 40°. The angle α was approximately 30°. If we assume ϕ to be 35°, then $F_2 = F_1$ (0.288). Thus if F_2 is 50 pounds, then F_1 must be 174 pounds to unlock the bolt.

Experimental values for F_1 and F_2 were determined with an Instron Testing Machine. Force F_2 was determined by latching the bolt and bolt carrier together in the lock position and recording the force required to pull them apart in the Instron Testing Machine. Force F_1 was determined by locking the bolt assembly in the receiver without the drive spring and recording the force required to unlock the assembly by pushing on the face of the bolt with a rod in the bore. The forces obtained are shown below.

G-3 Weapons	F_1 (lb)	F_2 (lb)
5.56mm (newer)	331	89
5.56mm (worn)	166	50

NOTE: F_1 is the force required on the face of the bolt to release the locking mechanism, lb.

F_2 is the force required on the connecting rod to release the locking mechanism, lb.

The variation in F_1 and F_2 was caused by wear on the lip of the bolt latch and difference in the strength of the bolt latch spring.

In actual operation the load on the face of the bolt exceeds 3000 pounds at the peak chamber pressure. The bolt is not completely unlocked, however, until the pressure in the chamber has past its peak, because of the inertia and friction of the mechanism. A lower value of F_2 allows earlier unlocking, resulting in a higher rate of fire because the velocity of the bolt assembly is increased moving out of battery.

Bolt Assembly Gap When the bolt assembly is locked in battery, there is a slight gap between the bolt and bolt carrier. The gap measured 0.014 inch on the newer 5.56mm weapon but only 0.008 inch on the worn 5.56mm weapon because wear in the locking recesses allows more roller protrusion and more connecting rod penetration. The 7.62mm weapon has a gap of 0.012 inch. This gap is designed to keep the bolt and bolt carrier from impacting with each other. If they were allowed to impact, two problems would arise. First, on coming into battery the bolt carrier would bounce off the bolt and might unlock the bolt assembly. Secondly, the initial force on the face of the bolt would be transmitted directly to the bolt carrier rather than through the rollers and connecting rod.

Special Features Some special features of the G-3 system are an open bolt catch and a damping device in the bolt assembly found only on the 5.56mm weapon and a fluted chamber and an unusual charging assembly found on both the 5.56 and 7.62mm weapons.

The open bolt catch is designed to hold the bolt assembly back after the last round of a magazine is fired. This notifies the firer that the magazine is empty and makes charging easier after the next magazine is inserted. The gun is charged by simply pushing the bolt release, located just forward of the trigger.

The damping device consists of lead filings in a cavity within the bolt carrier as shown in Figure 13. The tubular section of the bolt carrier is made of two thin-walled concentric cylinders with a space between for the filings. The lead filings help to damp the bounce of the bolt carrier when it impacts. The lead filings accounted for 0.12 pound of a total weight of 1.20 pounds for the bolt assembly.

The fluted chamber reduces friction between the cartridge case and the chamber walls allowing the cartridge case to be extracted from the chamber easily.

The charging assembly of the G-3 system is forward on the weapon and rides in a cylindrical channel above the barrel. It consists of a

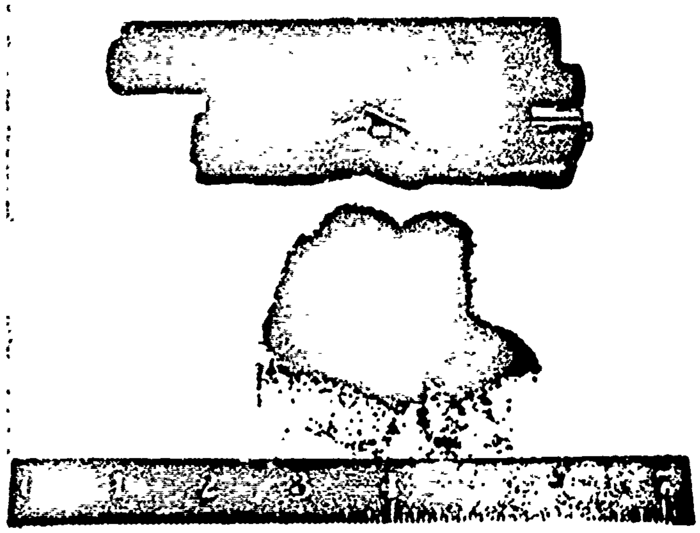

Figure 13. Bolt Assembly with Lead Filings for Damping, 5.56mm, G-3

heavy metal tube, which butts on the tubular section of the bolt carrier, and a charging handle as shown in Figure 14. The charging handle provides the initial leverage needed to unlock the bolt assembly when charging.

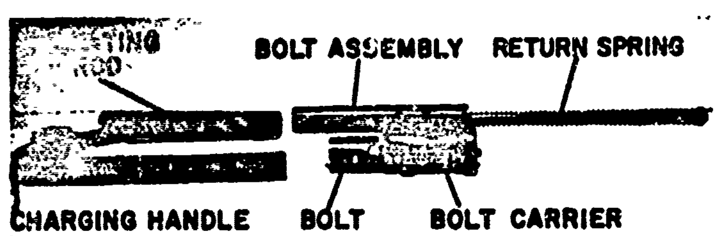

Figure 14. Charging Assembly and Bolt Assembly, 5.56mm, G-3

C. Malfunctions

A malfunction is defined as any abnormality of operation, or failure of any component of the weapon system, either structural or kinematic. A serious malfunction is one that produces a stoppage.

In 859 rounds fired (243 rounds with the 7.62mm; 515 rounds with the newer 5.56mm; 101 rounds with the worn 5.56mm) there were no malfunctions that produced stoppages except those which were induced by modifying the mechanism. A table of malfunctions is given below, followed by an explanation of each type of malfunction.

Table V. Malfunctions

G-3 Weapons	Condition	Malfunction	No. of Malfunc.	No. of Stoppages
5.56mm (newer)	Oiled	Failure of open bolt catch	10	0
5.56mm (newer)	Dry	Failure of open bolt catch	2	0
5.56mm (worn)	Oiled	Failure of open bolt catch	3	0
5.56mm (newer)	Dry	Short travel	4	0
7.62mm	Dry	Excessive delay	5	0
7.62mm	Oiled	Excessive delay	3	0
5.56mm (newer)	Oiled	Broken drive spring washer	1	0
5.56mm (worn)	Oiled	Broken drive spring washer	2	0
5.56mm (worn) w/modified mech)	Oiled	Failure to eject	2	2

Failure of Open Bolt Catch The open bolt catch failed to operate 15 times out of roughly 80 chances. There were no instances of the open bolt catch working before the last round of a magazine was fired however, so the malfunction did not cause a stoppage. The open bolt catch, which is part of the trigger mechanism, is activated when the magazine follower trips a sear which allows the bolt catch to spring into position. The sear is not always tripped off because of the lack of guidance of the magazine follower.

Short Travel A cycle was defined to have short travel if the bolt assembly did not reach the backplate after firing the round. To carry out all the functions of a cycle the bolt assembly must travel at least 3.58 inches from battery in the 5.56mm weapon. The shortest travel recorded was 5.60 inches. Four short travels occurred during the test, all with the newer 5.56mm weapon in the unlubricated condition. The stronger spring in the locking mechanism of the newer rifle, the lack of lubrication, and the softness of the gun mount combined to cause the short travels. The movement of the weapon in the mount subtracts from the velocity of the bolt assembly as the first round fires, but in succeeding cycles the weapon motion adds to the velocity of the assembly moving out of battery. Figure 15 shows the displacement of the bolt carrier and the receiver. Notice that on the first round, the bolt assembly does not reach the buffer. Ten bursts were fired from the shoulder with the mechanism lubricated and no short travels occured.

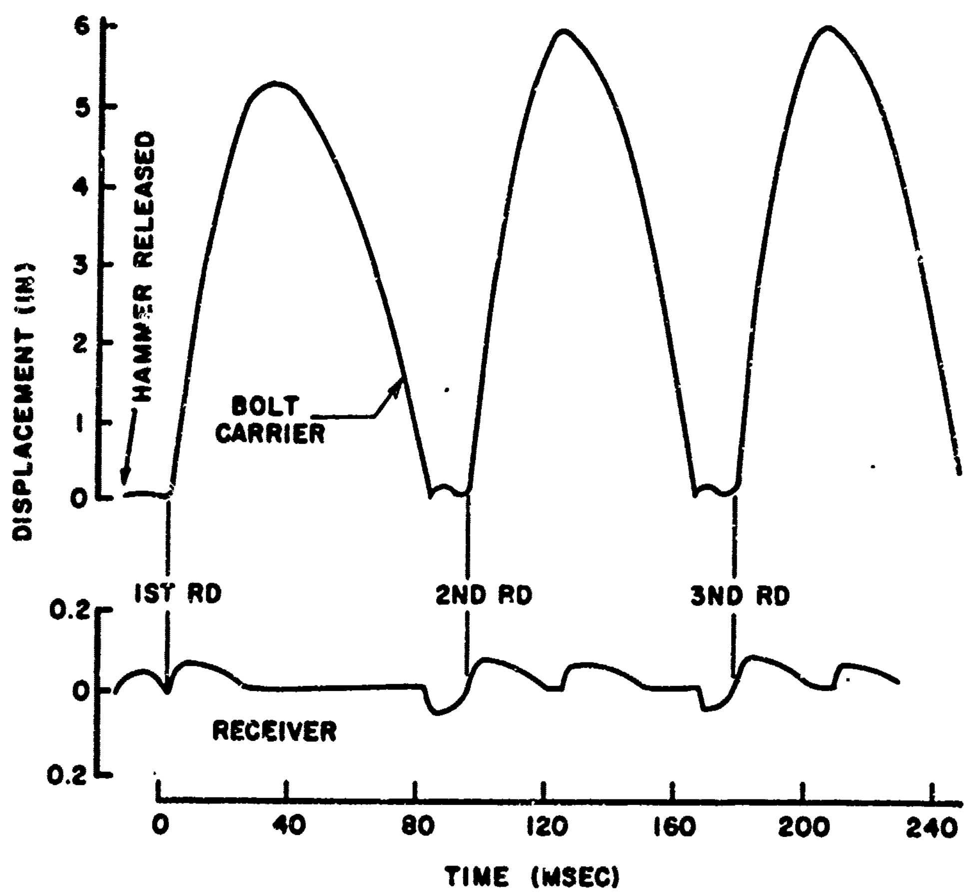

Figure 15. Displacement-Time Record of Bolt Carrier, 5.56mm, G-3, without Lubrication.

Excessive Delay After the bolt assembly comes into battery there is a delay before the round is fired. The hammer is released just before the bolt assembly reaches the battery position and normally takes about

11 milliseconds to complete its swing. A delay of longer than 15 milliseconds was considered excessive, indicating either the hammer did not release at the correct time or the hammer was interfered with during its swing. The excessive delays averaged 29.4 milliseconds. It seems most likely that the hammer was not released at the proper time. Since this malfunction did not show up on the 5.56mm weapons and no stoppages resulted, a thorough investigation was not made and the cause of excessive delays was not determined. Figure 16 shows the bolt carrier displacement with a normal and excessive delay.

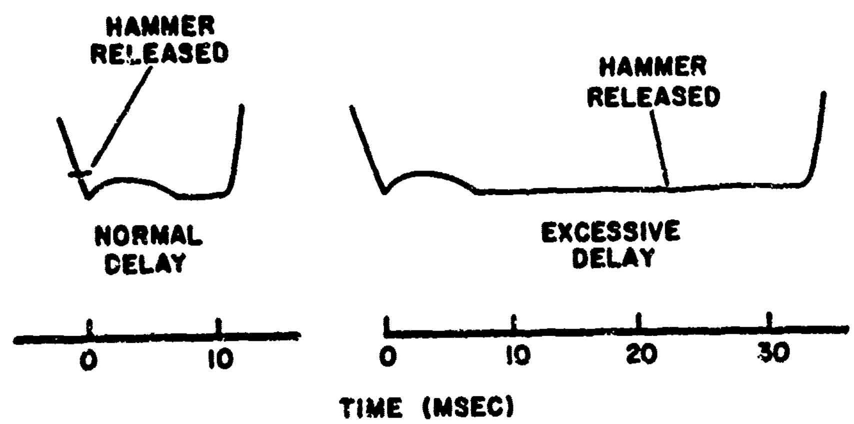

Figure 16. Bolt Carrier Displacement with Normal and Excessive Delays, 7.62mm, G-3

Breakage of Drive Spring Washers The drive spring of the 5.56mm weapon is held at either end by nylon washers and the flanged ends of the spring guide. Although the washers are not absolutely necessary because the flanges of the spring guide alone will hold the spring, they cushion the ends of the spring and keep them from deforming. Breakage of the washers did not cause a stoppage, but had a piece of the washer fallen into a sensitive area of the mechanism, a stoppage could have resulted.

Failure to Eject The two failures to eject cannot be counted as legitimate malfunctions because they were a result of modifications made in the mechanism to study the effects of increasing the rate of fire. Modifications increased the velocity of the bolt assembly causing the ejector lever to punch through the rim of the empty cartridge case rather than ejecting it.

D. Firing Data

In order to investigate possible problem areas, much of the firing of the 5.56mm weapon was done with modifications in the mechanism. The modifications included removing the lead filings from the bolt assembly, adding a steel shim between the bolt and bolt carrier, and interchanging parts from the newer and worn weapons. The lead filings were removed for two reasons; to reduce the mass of the bolt assembly and hence increase the rate of fire, and to increase the bounce of the bolt carrier upon impact by eliminating the damping. A shim was used between the bolt and bolt carrier to ease unlocking and to further increase the bounce of the bolt carrier upon impact. The shim eliminates the gap between the bolt and bolt carrier so that the initial motion of the bolt after firing is transmitted directly to the bolt carrier through the shim rather than through the rollers and connecting rod. The worn and newer bolt assemblies were used interchangeably with each of the 5.56mm receivers to determine which components are subject to extreme wear, and what effect this wear has on functioning. In some instances all of these modifications were used simultaneously.

Rate of Fire Table VI gives the rates of fire for the three weapons tested with no modifications on the mechanisms. The weapons were fired from the machine rest unless otherwise stated.

Table VI. Rates of Fire

G-3 Weapons	Condition	Rate (SPM)	N	σ_R (SPM)
7.62mm	Oiled-Clean	601	40	37
7.62mm	Oiled-Dirty	604	43	13
7.62mm	Dry-Clean	593	40	31
7.62mm	Dry-Dirty	580	36	43
5.56mm (newer)	Oiled-Dirty	775	6	20
5.56mm (worn)	Oiled-Dirty	879	13	29
5.56mm (newer)	Dry-Dirty	742	15	68
Shoulder Fired				
5.56mm (newer)	Oiled-Dirty	755	9	15

NOTE: N is the number of rounds in the statistical sample

σ_R is the standard deviation in rate of fire, shots per minute (SPM)

First round cycles were generally slower than cycles of succeeding rounds in a burst. The first round cycles of the newer 5.56mm weapon, when fired dry, were especially slow because of a number of short bolt assembly travels. This is attributed to reduced crush-up of the cartridge case on the first round because it is chambered only with the energy of the driving spring from the sear position. As a result, the clearances in the locking rollers are reduced causing unlocking to be more difficult and the velocity of the bolt in recoil to be decreased. Rates of fire of first cycles and succeeding cycles are given in Table VII. Rates are given in shots per minute (SPM).

Table VII. Rates of Fire with Modifications
Comparison of Initial & Succeeding Cycles

G-3 Weapon	Lubrication	First Cycle			Succeeding Cycles		
		Rate (SPM)	N	σ_R (SPM)	Rate (SPM)	N	σ_R (SPM)
7.62mm	Oiled	598	9	20	601	18	26
7.62mm	Dry	575	8	21	585	16	25
5.56mm (newer)	Oiled	757	2		785	4	
5.56mm (newer)	Dry	664	5	28	788	10	16
5.56mm (worn)	Oiled	862	6	20	894	7	29

The mechanism modifications made on the two 5.56mm weapons affected their rates considerably. Table VIII shows the rates of fire obtained under various conditions. From Table VIII we see that substituting the worn bolt assembly in the newer weapon increases the rate of fire from 775 to 866 shots per minute. The increase was expected because the locking mechanism of the worn bolt assembly is much weaker than that of the newer one, as explained earlier.

Removing lead filings from the newer bolt assembly changed its weight from 1.20 to 1.08 pounds. The reduction in weight increased the rate of fire from 775 to 936 shots per minute.

Table VIII. Rates of Fire with Modifications

Newer 5.56mm Assault Rifle, Oiled-Dirty

w/Newer Bolt Assembly							w/Worn Bolt Assembly						
w/ filings	w/o filings	w/ shim	w/o shim	Rate (SPM)	N	σ_R	w/ filings	w/o filings	w/ shim	w/o shim	Rate (SPM)	N	σ_R
X	—	—	X	775	6	20	X	—	—	X	866	3	
—	—	—	—	—		—	X	—	X	—	877	8	26
—	X	X	—	998	4	—	—	—	—	—	—	—	—
—	X	—	X	936	25	16	—	—	—	—	—	—	—

Worn 5.56mm Assault Rifle, Oiled-Dirty

w/Newer Bolt Assembly							w/Worn Bolt Assembly						
w/ filings	w/o filings	w/ shim	w/o shim	Rate (SPM)	N	σ_R	w/ filings	w/o filings	w/ shim	w/o shim	Rate (SPM)	N	σ_R
—	—	—	—	—	—	—	X	—	—	X	879	13	29
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	X	X	—	991	13	33	—	—	—	—	—	—	—
—	X	—	X	932	5	19	—	—	—	—	—	—	—

The wear of the receiver did not seem to affect functioning appreciably. For instance, when the newer bolt assembly was used in the worn weapon the rate of fire was comparable to that with the newer bolt assembly in the newer weapon.

The shim, which was 0.018 inch thick, caused the rate of fire to increase only 10 to 50 shots per minute.

Bolt Assembly Velocity The velocity of the bolt assembly and rate of fire are proportional. That is, the faster the bolt assembly moves through the cycle, the higher the rate of fire will be. The velocity of the bolt assembly must be within certain bounds however. For instance, if the velocity of the bolt assembly is too high when it reaches the ejector lever the empty case may be punctured rather than ejected. On the other hand if the velocity just out of battery is too low a short travel may result. Velocities of the bolt assembly are shown in Table IX under different firing conditions. The values given represent the maximum velocity just out of battery.

Table IX. Bolt Assembly Velocity

G-3 Weapons	Lubrication	Condition	Velocity (fps)	N	σ_v (fps)
7.62mm	Oiled	Fired from Machine Rest	24.2	20	0.9
5.56mm (newer)	Oiled	Fired from Machine Rest	—	—	—
5.56mm (worn)	Oiled	Fired from Machine Rest	25.0	6	1.1
5.56mm (newer)	Oiled	Fired from Shoulder	24.6	9	1.2
5.56mm (newer)	Dry	Short Bolt Travel	22.0	4	—
5.56mm (worn)	Oiled	Failed to Eject	39.7	2	—

NOTE: σ_v is the standard deviation in velocity, ft per sec (fps)

Figure 17 shows a plot of the displacement and velocity of the bolt assembly versus time, for a typical cycle of the 5.56mm.

Bolt Carrier Bounce Bolt carrier bounce is of interest because it could conceivably cause failure to fire if excessive. As the bolt assembly comes into battery the bolt hits the face of the breech and rebounds. Before the bolt can bounce very far however, the incoming

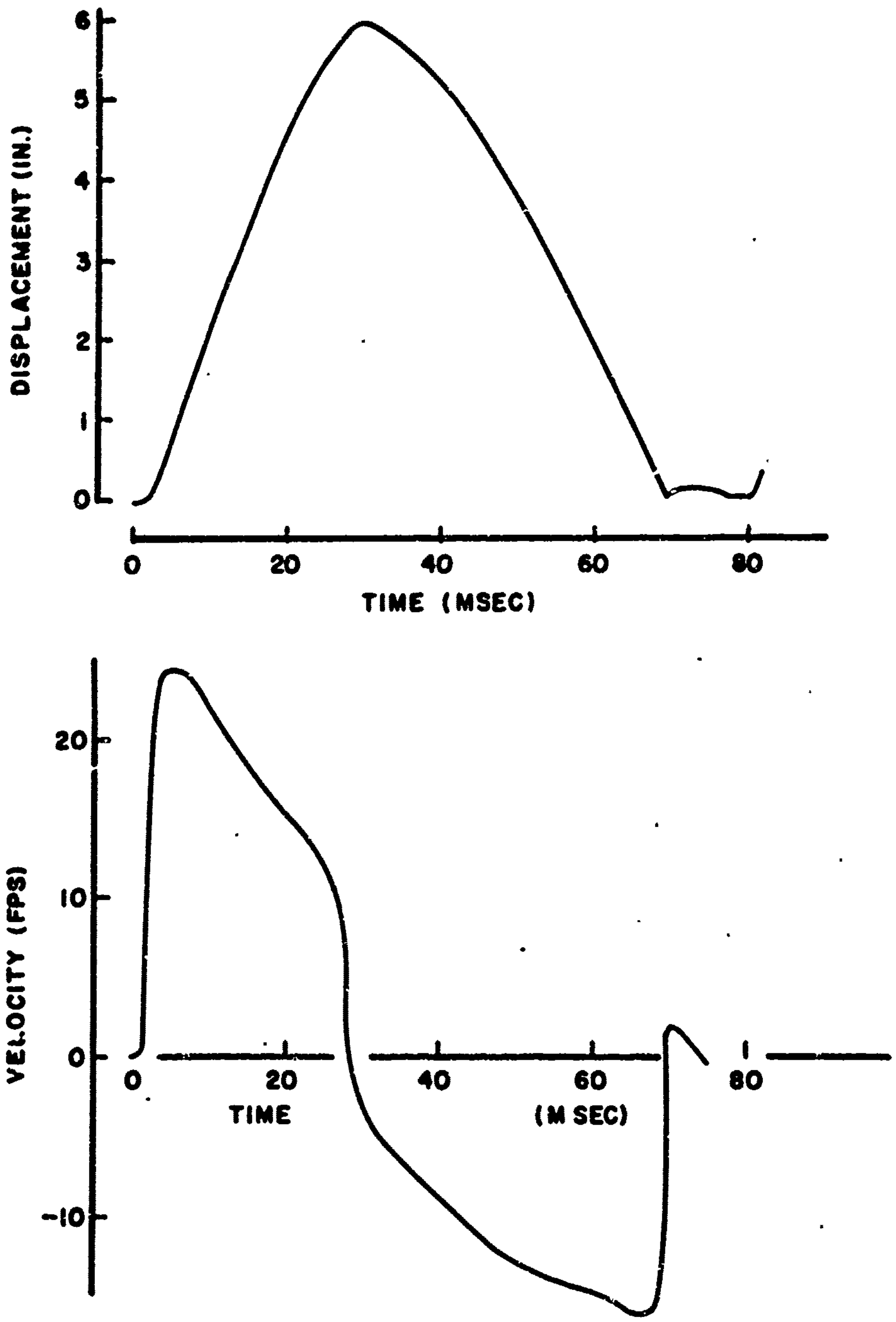

Figure 17. Displacement and Velocity of Bolt Carrier, 5.56 MM, G-3.

bolt carrier drives it back against the face of the breech. When the bolt is completely locked, the bolt carrier itself bounces back somewhat. If the bolt carrier were to bounce back excessively, the bolt assembly would partially unlock. Hence the bolt assembly could be out of battery when the hammer strikes, causing a misfire. Figure 18 shows a displacement-time record of the bolt and bolt carrier near the battery position.

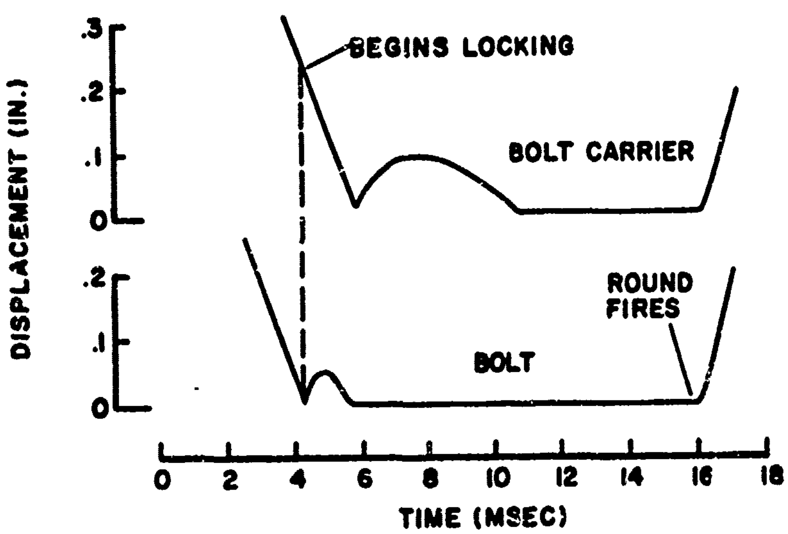

Figure 18. Bolt and Bolt Carrier Bounce

In order to cause unlocking, the bolt carrier must bounce back at least 0.12 inch from battery on both weapons. Table X shows the size of the bounces obtained under the various conditions tested. Removing the lead filings from the worn bolt assembly caused the bounce to increase from 0.067 to 0.091 inch.

The shim, which was used to eliminate the gap between the bolt and bolt carrier in battery, increased the rate of fire as shown earlier, but did not increase the bounce as expected. In fact the bounce was reduced considerably because the shim was too soft and acted as a

Table X. Bolt Carrier Bounce

Newer 5.56mm Assault Rifle, Oiled-Dirty

w/Newer Bolt Assembly					w/Worn Bolt Assembly				
w/ filings	w/o filings	w/ shim	w/o shim	Bounce (inch)	w/ filings	w/o filings	w/ shim	w/o shim	Bounce (inch)
X	--	--	X	0.067 ±0.005	X	--	--	X	0.077 ±0.012
--	--	--	--	------	X	--	X	--	0.045 ±0.007
--	X	X	--	0.045 ±0.007	--	--	--	--	------
--	X	--	X	0.091 ±0.005	--	--	--	--	------

Worn 5.56mm Assault Rifle, Oiled-Dirty

w/Newer Bolt Assembly					w/Worn Bolt Assembly				
w/ filings	w/o filings	w/ shim	w/o shim	Bounce (inch)	w/ filings	w/o filings	w/ shim	w/o shim	Bounce (inch)
--	--	--	--	------	X	--	--	X	0.077 ±0.007
--	--	--	--	------	--	--	--	--	------
--	X	X	--	0.067 ±0.008	--	--	--	--	------
--	X	--	X	0.085 ±0.010	--	--	--	--	------

7.62mm Assault Rifle Bounce = 0.085 ±0.003 inches cushion between the bolt and bolt carrier.

Recoil Impulse The recoil impulse of the 7.62mm and the newer 5.56mm weapons was measured in the ballistic pendulum. As shown in Table XI, the recoil impulse varies with the lot of ammunition used.

Table XI. Recoil Impulse

G-3 Weapons	Condition	J lb sec.	N	σ_J lb sec.	Lot of Ammo
7.62mm	w/ muzzle device	2.638	5	0.0199	WCC-6007
7.62mm	w/o muzzle device	2.595	6	0.0107	WCC-6007
5.56mm (newer)	w/ muzzle device	1.269	6	0.0140	RA 5072
5.56mm (newer)	w/o muzzle device	1.206	6	0.0081	RA 5072
5.56mm (newer)	w/ muzzle device	1.328	8	0.0088	RA 5089
5.56mm (newer)	w/o muzzle device	1.272	6	0.0010	RA 5089

NOTE: J is the recoil impulse, lb sec
σ_J is the standard deviation in measured recoil impulse, lb sec

Muzzle Vibration Muzzle vibration was not appreciable. The muzzle reached its maximum amplitude after the third round of a burst. The displacement-time record of vertical muzzle vibration shown in Figure 19 was obtained with the newer 5.56mm weapon.

Projectile Dispersion Targets were placed 63 feet from the muzzle. Figure 20 shows the comparative dispersion patterns obtained when firing five, ten-round bursts from both the 7.62mm and the newer 5.56mm weapon.

Projectile Velocity Projectile velocities at the muzzle are given in Table XII for the 7.62mm and the newer 5.56mm weapons. Values are given with and without muzzle devices.

Table XII. Projectile Velocity

G-3 Weapons	V_M fps	N	σ_J fps	Lot Of Ammo
7.62mm	2709	8	33	WCC-6007
7.62mm	2689	12	35	RA 5055
5.56mm (newer)	3021	5	42	RA 5072
5.56mm (newer)	2998	14	61	RA 6089

NOTE: V_M is the muzzle velocity of the projectile, ft per sec (fps)

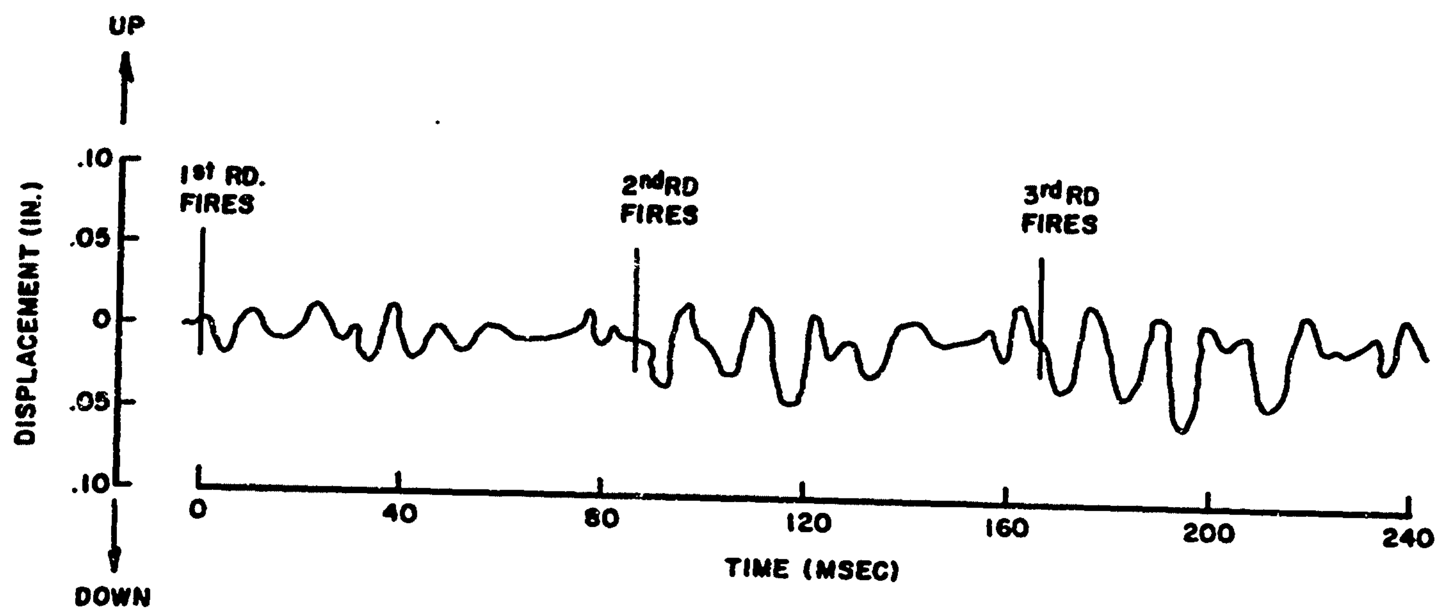

Figure 19. Vertical Muzzle Motion of Newer 5.56 MM, G-3.

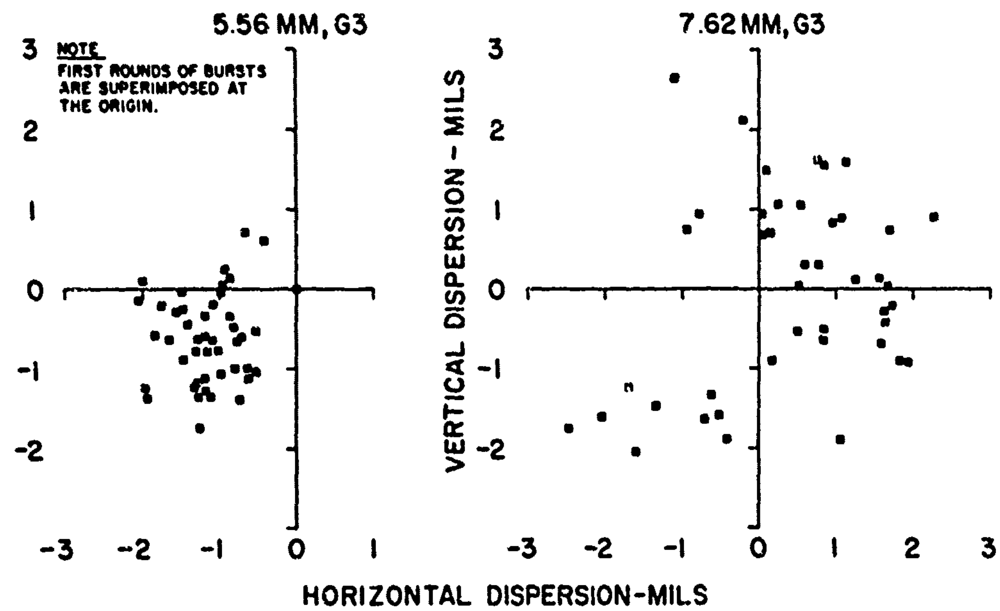

Figure 20. Dispersion Patterns of Five, 10 Round Bursts

IV. DISCUSSION

A. Reliability

In automatic weapons, stoppages are most likely to occur during a cycle that is slower or faster than average. Therefore it is important that cycles be uniform from round to round. It is equally important, however, that the weapon have a margin of flexibility in cycling so it can continue to fire even if conditions force a higher or lower rate of fire.

The results of this study indicate that the G-3 system is quite reliable. Table IX, giving velocities of the bolt assembly of the 5.56mm weapons under different conditions, demonstrates the margin of flexibility in the firing cycle. The initial velocity of the bolt assembly is normally 24 to 25 feet per second with 5.83 inches of travel. By reducing the weight of the bolt, the velocity was increased to 40 feet per second. This produced a marginal condition causing failures to eject on some rounds. By completely removing the oil from all parts of the mechanism in the newer weapon, the initial velocity was reduced to a minimum of 22 feet per second with a minimum travel of 5.60 inches. Only 3.60 inches of travel is required for feeding and stripping indicating the weapon will function with a bolt assembly velocity considerably less than 22 feet per second. Compared to other automatic weapons, the variations that can be tolerated in the cycling of these weapons is extremely large. The weapons should continue to fire under adverse environmental conditions and with large variations in the interior ballistic performance of the ammunition.

The weapons fire equally well whether dirty or clean as illustrated by the rates of fire given in Table VII. This is significant since the mechanisms become heavily coated with carbon after only a few rounds are fired, because of the blowback operation and the fluted chamber. A lack of lubrication reduces the rate of fire only 10 - 20 shots per minute.

B. Performance

The relatively short barrel of the G-3 Assault Rifle limits the projectile velocity that can be obtained from the 5.56mm cartridge. The 5.56mm, G-3, for instance, has a barrel length of about 16 inches which is approximately three inches less than that of the M-16.

C. Bolt Latch

The bolt latch, which locks the bolt and bolt carrier together in battery, is a key component in the functioning of the mechanism. As the lip of the bolt latch wears and the bolt latch spring becomes weaker, unlocking becomes easier and the rate of fire increases.

D. Bolt-Bolt Carrier Gap

The gap between the bolt and bolt carrier decreases with wear. The gap measured 0.014 inch on the virtually new 5.56mm weapon and 0.008 inch on the worn 5.56mm weapon. This variation had little or no effect on functioning. If the gap were eliminated altogether however, the unlocking process would be altered, as described earlier.

E. Possible Changes

The open bolt catch should be redesigned. As it is now the magazine follower does not always make contact with the sear and release the catch.

The charging handle might also be changed. It tends to bind when charging, especially with the worn 5.56mm weapon.

F. Damping Device

The damping device in the bolt assembly seems to work quite well. It reduces the bounce of the bolt carrier considerably. The bounce did not reach a serious level though, even when the lead filings were removed from the bolt assembly.

G. Weight

Both the 7.62mm and the 5.56mm weapons are slightly heavy when compared to similar weapons as can be seen in the table of weights. The weight could be reduced by making the stock and foregrip out of fiberglas and perhaps making the trigger mechanism out of aluminum. A simpler charging assembly might also reduce the weight.

REFERENCES

1. H. P. Gay, Displacement-Time Recorder. BRL Report No. 610, June 1946.

2. H. P. Gay, Notes on Techniques and Apparatus for Investigating the Effects of Recoil and the Stability of Mounts for Small Arms Weapons. BRL Memorandum Report No. 955, December 1955.

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13. ABSTRACT

A test was conducted with 7.62mm and 5.56mm, G-3 Assault Rifles to evaluate and compare the kinematics, reliability, safety features, physical characteristics, recoil impulse, rates of fire, projectile velocities, muzzle motion and accuracy of the weapons. No serious problems were detected during the tests and the reliability of the weapons was comparable. (U)

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